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ABSTRACT

Perhaps the most dramatic failure in postsecondary education has been in the teaching of mathematical skills. The different functions of the right and left hemispheres of the brain require different approaches to education. Due to their emphasis on language and verbal processing, schools have failed to give adequate stimulation to the right side of the brain and thus tend to discriminate against right brain (RB) dominant students. Many students show a preferred RB (intuitive) thinking style and consequently have struggled in school because their thinking style did not conform to typical left brain (LB) or logic-based instruction and testing. LB dominant students were generally successful in algebra, while RB students tended to succeed in classes involving trigonometry, conics, vectors, and complex numbers. Findings of one study show that in a beginning calculus course, 70% of unsuccessful students were LB, even though there was no significant difference in successful LB versus RB students. Although there has been research which casts doubt upon the validity of the LB/RB distinction, it is clear that students approach problem solving from either an intuitive or logical point of view, and educators must accommodate both learning styles. Instructors must teach students the difference between LB and RB styles of thinking. They should show how different thinking styles could have led to negative classroom experiences which in turn could be at least partly responsible for a difficulty in learning math. A list of 25 references is included. (MAB)

REVIEW OF

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Left Brain/Right Brain Theory: Implications For Developmental Math Instruction

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Perhaps the most dramatic failure in postsecondary education has been in the teaching of mathematical skills. Many students, and even college/university faculty, admit to math anxiety and fundamental math skills deficiencies. The proliferation of developmental mathematics courses, of supplemental support math programs, and of larger populations of students retaking courses testifies to the prevalence of math background deficiencies among students entering college. The high failure rate in math courses and their perceived difficulty indicate a need for new approaches to the teaching of these courses. Relatively recent research investigating students' learning styles suggests some strategies and approaches offering hope to otherwise unsuccessful students. Among the many theories attempting to explain how the diversity in student learning styles can be addressed to improve learning is left-brain/right-brain (LB/RB) theory. In particular, the LB/RB hypothesis accounts for tendencies of many students who practice math avoidance or experience math anxiety in response to exposure to typical mathematics instructional approaches. Attention to this research together with observations of these students' learning problems has inspired math instructors to invent approaches that are more palatable to many students and often, therefore, more effective. This monograph will review the professional literature concerning LB/RB learning theory. Next, focusing on students who encounter problems learning mathematics, it shall demonstrate how LB/RB theory can be viewed as a reasonable and plausible explanation for failure of certain students who undergo typical mathematics instruction. Finally, it will explore some instructional alternatives.

Background

As early as the 1860's, brain specialists observed that damage to one hemisphere of the brain would selectively interfere with specific abilities (Edwards, 1979; Gray, 1980; Springer & Deutsch, 1985; Wonder & Donovan, 1984). When it was noted that damage to the left cerebral hemisphere could result in the loss of language functions and damage to the right cerebral hemisphere could interfere with visual-spacial recognition, left-brain/right-brain (LB/RB) theory was born. Substantial research over the last 100 years has verified a separation of functions between the hemispheres (Wonder & Donovan, 1984). Several authors have described the characteristics of each side of the brain (Ornstein, 1977; Williams, 1983; Wonder & Donovan, 1984). The left hemisphere is analytical and logical, it specializes in recognizing the parts, it is linear and sequential, and it processes in a step-by-step manner. The right hemisphere is intuitive, creative, imaginative, and artistic, recognizing the whole as opposed to the parts. It is engaged in synthesis and seeks, recognizes, and constructs patterns and relationships. The right hemisphere is more efficient at image processing but is very limited in language capacity. It has been compared to a kaleidoscope, whereas the left hemisphere has been compared to a computer. Hatcher (1983) reports, "We know that the right brain cannot verbalize what it knows" and "the left brain...is unable to create meaning or generate new ideas" (p. 9). This contrast suggests the need for whole-brain thought if complete functioning is to occur.

Some Applications of Right/Left Brain Theory

Our society and school system do not encourage right-brain (RB) thinkers (Hart, 1978). Larson (as cited in Ellis, 1985, p. 155) refers to great innovative RB thinkers as "notable failures." He reports that Albert Einstein was four years old before he could speak, that Werner von Braun failed 9th grade math, and that Thomas Edison was told he was too stupid to learn anything. These are only three on the list of RB "notable failures" who are now famous for their accomplishments. Williams (1983) argued, "The brain has two hemispheres but too often the education system operates as though there were only one" (p.7). Due to their emphasis on language and verbal processing, our schools have failed to give adequate stimulation

to the right side of the brain and tend to discriminate against "right-brain dominant" people (Hart, 1983). Williams contends that this is a mistake because "right-brain thinking is essential to problem solving and creativity" (p.7).

Split-brain theory offers many observations and suggestions for increasing student achievement (Sylwester, Chall, & Wittrock, 1981). Grady and Luecke (1978) feel that developing both "the linear mode of consciousness" of the LB and the "holistic mode of consciousness" of the RB will increase student achievement. Lord (1984) points out that academic success is often influenced by students' ability to use the proper brain hemisphere. Gray (1980) cites evidence of dominant right hemisphere functioning in some students, whereas others have thinking styles which are dominated by the left hemisphere, and she speculates that many RB students are turned off by LB instructional strategies. Hart (1981) also laments the "conventional style of authoritative teaching" (p. 505) and its emphasis on right answers, arguing that education should provide more stimulation of the whole brain. These findings and constructs strongly suggest that as teachers we need to learn what thinking style is preferred by our students so we do not continually ignore their strengths when we plan lessons and select materials.

Samples (1975a, 1975b) reports positive results from providing a desirable environment for RB learning, including improved self-esteem and simultaneous increases in "left-brain skills." Williams advocates more "direct experience," which would allow students to approach a subject more holistically, by placing more emphasis on labs, simulations, and role play. However, few definitive studies have been completed to support the numerous suggestions for change. Accordingly, there is an unfortunate lack of statistical research to verify the observations of these educators who have argued for LB/RB consideration.

Left-Brain/Right-Brain Theory and Mathematics

Lord (1984) cited evidence that "right-hemisphere functions, such as holistic problem solving and imagery manipulation, tend to be called upon in mathematical and scientific subjects. Creswell, Gifford, and Huffman (1988) have presented techniques for developing RB functioning in mathematics. Researchers have found that successful students of physics, chemistry, and biology tend to have high right-hemisphere conceptual aptitudes" (p. 101). Other LB/RB proponents have credited the left side of the brain for our ability to sequence and to process mathematical concepts. Fry, Languis, and Cobbs (1988) have summarized characteristics of two learning styles in mathematics; the opposing characteristics of these two learning styles conform to the traditional attributes of LB versus RB domination. Williams (1983) also alludes to these two learning styles and to the contention that math teachers should both diagram and "talk through" mathematical processes so that students could simultaneously see and hear solutions. Grady and Luecke (1978) give five guidelines for teachers who are interested in developing both visual and verbal thought. It would appear that these authors are recommending very similar practices, whether or not they consistently describe them as based in LB/RB theory.

The works of Cynthia Miller are the only quantitative studies we found of LB/RB differences in the college classroom. She reported (1987) that in college algebra LB dominant students were generally successful while the unsuccessful students were usually RB. She found the reverse to be true in courses which involve trigonometry, conics, vectors, and complex numbers. She reported that in beginning calculus 70% of the unsucccessful students were LB even though there was no significant difference in successful LB versus RB students. In a subsequent study, Miller (1988) investigated whether lateralization exercises would have an effect on achievement in college calculus. She found that the RB students outperformed the LB students, but the differences were not significant. However, "course grades were significantly higher when students' hemispheric laterality matched their treatment group" (p.7): that is, RB students doing RB exercises and LB students doing LB exercises.

Controversy

There are some who do not recognize the value of LB/RB theory. Hines (1985) contends that there is no real evidence that the left hemisphere is "logical" and the right hemisphere is "intuitive." He argues that "attempts to improve performance and training relying on nonexistent left-brain/right-brain differences are unlikely to be productive" (p. 35). Levy (1985) and Lynch (1986) also characterized the LB/RB concept as a myth. Sergent (1982) has obtained evidence that the specialization of the hemispheres is more complex than was first thought; he believes that the strength of the stimulus is as important as the type of stimulus in determining which hemisphere processes the information.

Yet, despite negative statements regarding its validity, the LB/RB distinction provides a simple and convenient basis for questioning our education system and for helping students. Whether each hemisphere is responsible for a certain typ of thinking is not the point. The point is that people naturally think in different ways: They approach problem solving either intuitively or logically. The math instructor who observes and understands this difference has the opportunity to recognize, and to help students to recognize, this tendency and to teach students to use alternate skills to complement their strengths. Thus, LB/RB theory is at least a meaningful metaphore through which we can learn to better understand and then deal with learning differences.

Discussion

There is ample evidence that math students at all levels should be taught brain lateralization at the same time mathematics is taught and that well designed studies should monitor their experience. It is possible that college mathematics beyond algebra becomes particularly difficult because LB dominant students, who were encouraged by previous successes in algebra which emphasizes LB skills, have difficulty with the visualizations which become necessary in higher mathematics. Accordingly, RB dominant students may avoid higher mathematics after being discouraged by previous difficulties with sequential processes. They may never reach the courses which would show their strength in spatial ability, and spatial ability "has been positively correlated with higher level mathematical ability" (Miller, 1988, p. 7). Thus we risk losing some of the

promising mathematical minds because they begin losing confidence in their own ability at some point in their education.

In arithmetic and beginning algebra courses, sample problems can be used to show the difference in LB and RB thought by contrasting the two thought processes. For example, if the problem is "find 125% of 80," the RB thought process is to find 100% of 80 and add it to 25% of 80 (done mentally). The LB approach is to move the decimal two places and multiply by 80; these steps are usually done on paper and are seldomly estimated for accuracy. Often RB thinkers will not learn the LB approach because it is slower and may require writing steps. They will then become frustrated with a problem like "find 1.3% of 7.9." The LB students will deal with this problem the same way they would the previous example, but the RB student may even be unable to begin the problem. Thus, in order to be able to work all of the problems involving a particular concept, the LB approach is effective and even necessary.

Teaching lateralization can continue in calculus and more advanced math courses. In such courses, LB students should be given methodology for visualization of concepts and interrelationships. Students need to be made aware that linear, sequential thought processes are not sufficient for understanding upper level mathematics, even though they were often successful in algebra.

One of the advantages of LB/RB theory is its simplicity and yet its profound relevance to success in mathematics and to the formation of students' self-image. Students can easily relate to, and even find humor in, a description of LB/RB behaviors. They can also identify with the negative experience of being a RB student with a LB math instructor who is ignorant of LB/RB differences, and they can see how these experiences could be the source of a person's negative self-image. Childhood experiences of using unsuccessful RB thinking where LB thinking would have yielded the answers may have caused failure on tests and frustration as early as elementary school. As college students, these RB individuals may believe that they have little mathematical ability when, in fact, they may have great potential. Beliefs affirmed at a young age affect a student's behavior and performance in the college classroom (McEntire & Kitchens, 1984). Sometimes, past experience may even have been so devastating that it induces negative self-images such as "I'm not a worthwhile person" or "I'm just dumb." However, understanding that an approach which encompasses whole-brain thinking can lead to success may begin to change a student's self-perception of inability in mathematics.

Conclusions

Left-brain/right-brain theory has become a key issue in teaching math and in particular in understanding the developmental math student. A high percentage of these students show a preferred RB thinking style and consequently have struggled in school because their thinking style did not conform to typical LB-based instruction and testing. From their experiences with teachers or parents, these students have developed an attitude of learned helplessness which becomes self-fulfilling and thus a formidable barrier to their learning.

Based upon our classroom experience as well as a review of the literature, we propose that math professors teach students the difference between LB and RB thinking and how to think in a "whole-brain way." Instructors should also support the idea that inability is not the cause of past failure, then relate how different thinking styles could have led to negative classroom experiences which could be at the root of a negative self-image and thus be at least partly responsible for a difficulty in learning math. Understanding how their natural way of thinking relates to their past difficulties can provide students with new hope for success in math, and provide the math professor with an enriching enhancement for teaching.

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